DOCUMENT RESUME

ED 176 236 CS 005 009

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TITLE Verbal and Non-Verbal Measures of the Understanding of Recursive Thought.
PUB DATE Feb 79
NOTE 8p.; Paper presented at the Annual Meeting of the International Interdisciplinary University Affiliate Program Conference on Piagetian Theory and Its Implications for the Helping Professions (9th, Los Angeles, California, February 2-3, 1979)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Development; *Cognitive Processes; Communication (Thought Transfer); Elementary Education; *Language Ability; *Measurement Techniques; *Nonverbal Ability; *Psychological Studies; Social Science Research
IDENTIFIERS *Recursive Thought

ABSTRACT

Four males and four females from each of grades one through six served as subjects in an investigation of the development of recursive thought (imagining other people's thoughts). One half of the subjects were asked to tell what a little boy in a picture was thinking about various configurations of faces. The remaining subjects were told the thought process and were asked to construct a picture of it using cutouts of faces and plastic "thought clouds" similar to those seen in cartoon strips. It was hypothesized that the language reception task would yield higher success than the language expression task for all grades, that decreasing success with increasing item complexity would be evident for both tasks, and that individual subjects would demonstrate decreasing success with increasing item complexity. The first hypothesis was accepted and the second two were rejected. Results indicated a two-level development of recursive thought when language expression is minimized, with contiguity and action thoughts comprising the first level and the second level including all higher recursive thinking. The results were conclusive in showing that development occurs at an age earlier than reported previously. (TJ)

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ED176236

Verbal and non-verbal measures of the understanding of recursive thought

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The study to be reported deals with one aspect of the development of social cognition. That aspect is the ability to imagine the probable contents of other's thoughts. The changing perception of other people from static objects to subjects in their own right involves an awareness of the kind of thinking in which these others can engage. This ability to imagine other person's thoughts has been termed "recursive thinking", or thinking about thinking, since it's structure can be hierarchical. An example of recursive thinking would be as folows: I think that you think that he thinks, etc.

Miller, Kessel and Flavell in 1970 proposed a four stage developmental sequence to the ability to understand and engage in recursive thinking. Step 1 in their sequence involves an understanding that others can think about static, contiguous people. Step 2 involves the understanding that other persons can think about people engaged in action with one another. Step 3 involves the understanding that one can think about thinking, which Miller et al have termed "one loop recursive thought". And step 4 involves the understanding that one can think about thinking about thinking, which they have termed "two loop recursive thought". However, the chains of loops can be indefinitely extended at this last stage of development.

The proposed developmental sequence (Miller et al) arose from a study in which they presented first to sixth graders with line drawings of a little boy thinking about various configurations of other people. Certain of the

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pictures represented stage 1 thinking and depicted the boy thinking about 1 to 3 different people. The pictures were drawn as a newspaper "cartoon" strip. Items representing stage 2 thinking depicted the boy thinking about people talking to one another. Stage 3, "one loop recursion" was represented by pictures of the boy thinking about another person thinking. Stage 4 items depicted the boy thinking about another's thoughts about someone else's thoughts. There were 18 picture items, each representing 1 of the 4 stages, each stage represented at least 4 times by different configurations of people.

The child's task was to verbally describe what the little boy was thinking. Correctness of the child's response depended on the accuracy of the words used to connect the verb phrases. For example, for a two loop item, a correct response would be "The boy is thinking that the girl is thinking of the father thinking of mother." An incorrect response might be "The boy is thinking that the girl is thinking of father and the father is thinking of mother." That is, the correct complex sentence structure that would most accurately describe the picture could be incorrectly transformed into a compound sentence or even a series of simple sentences. The authors assumed that if the pictures were not described according the verbal criteria they set forth, then this was an indication that the child did not understand the dynamics of the cognitive processes represented in the picture, and therefore had not fully reached that particular stage in the development of the understanding of recursive thought.

The hypothesis that there was an invariant sequence to the 4 steps was confirmed according to these authors. Their conclusions were based on two main results. First, with increasing grade level, success on the higher, that is the more complex items, became more likely. Secondly, 91% of their subjects showed a decreasing proportion of correct responses with increasing order of item complexity. Also, they found that full development of the

ability to understand recursive thinking had not nearly been reached even in their sixth grade subjects.

In considering this study, we felt that first, one of their statistical treatments was not appropriate, and second, their methodology may have underestimated children's ability to understand recursive thinking. The statistical problem will be discussed later when the results of our study are reported. The methodological problem was the main reason for our replication and further investigation of the Miller et al study.

As you will note, their method of measuring the target cognitive ability was via the child's verbal production. Since language is a developmental phenomenon that typically undergoes change well into the 11th or 12th year, and since their subjects ranged in age from approximately 6 through 12, it is reasonable to supposed that language competance played a significant role in the child's correctness in describing the pictures. It is quite possible that given a picture of a one loop recursive thought process, for example, the child could have partial if not complete understanding of what is represented in the picture. But hindered by his/her language expressive abilities; the child's verbal response might be inadequate in describing the represented cognitive process. Since Miller et al's task was so heavily verbal and as expressive language ability of children in this age range is not fully developed, it is probable that the Miller et al task underestimated that ability to understand recursive thinking.

The problem then, was to tap into the child's understanding of recursive thought while minimizing the distortion in measurement caused by the use of language expression as a measure. Since language understanding or language reception is an earlier developmental ability than language production, one might expect the measurement of the understanding of recursive thought to show some differences when using a language receptive task as opposed to a language expressive task. Although in a reception task, language itself would

not be eliminated, the measured understanding of recursive thought should be less distorted.

We then designed a task that relied on children's language receptive abilities as a measure of the understanding of recursive thought and compared it with the language expression task used in the Miller study. The subjects in our study were 4 males and 4 females from each of grades 1 through 6 for a total of 48 subjects. Two tasks were used: one relying on language receptive abilities, and the other relying on language expressive abilities.

The language expression task was a replication of Miller et al's measure, using 18 pictures of a little boy thinking about various configurations of faces. One half of the subjects were randomly assigned to the expression task. After a period of familiarization with the materials, subjects were shown each of the cards seperately and asked to tell what the little boy was thinking. Scoring for this task was the same as used in the Miller et al study--the verbal structure of the subject's response served as the measure of whether or not the subject understood the picture, and hence the cognitive process represented. All responses were tape recorded for later scoring.

The language reception measure which we designed was basically a reverse of the expression task. The remaining subjects were randomly assigned to this condition. Here, the subjects were told the thought process by the experimenter and were asked to construct a picture of it, using cut-outs of faces and plastic "thought clouds", as one would see in a cartoon strip. That is, E verbalized to the subject what the little boy was thinking and the child's task was to arrange the cut-out faces and "clouds" on a board in such a way as to represent the cognitive process that E described. Each subject constructed their understanding of the cognitive process by arranging the cut-outs on the board. The same 18 items were used in this reception task, except that the items were the verbal descriptions of the boy's thoughts. The subjects' picture constructions were scored as either Pass or Fail on the basis

of whether or not they accurately portrayed the theme of the verbalized item. "Accuracy" was defined as identity to or very close similarity to the picture items used in the expression tast. We assumed that if the child were unable to construct an accurate picture of E's description of the thought process, then this indicated that the child did not understand the cognition, and hence had not fully reached that particular "stage" in the development of recursive thought (as postulated by Miller et al, 1970).

Hypothesis 1 predicted that the language reception measure would yield higher success rates on all item groups than the language expression measure. The hypothesis was confirmed on the following bases.

We calculated how successful at each grade level subjects were, regardless of item grouping. At all grade levels, the reception subjects performed more successfully than the expression subjects. This difference ranged from 4% at grade 1 to 39% at grade 3. For the reception subjects, the average correct responses was 86% as compared to 64% for the expression task subjects. Chi squares showed that this overall greater success for the reception task subjects was highly significant. Further chi square analyses showed that this difference in success between the two tasks lay in the subject's performance on the one loop and the two loop items, and not the contiguity or action items. These results would indicate that while the reception task led to higher overall success than the expression task, this greater success was accounted for by the difference in performance on items representing stages 3 and 4 and not on items representing stages 1 and 2. We concluded therefore, that measurement strategy had no significant effect on the subjects' performance on the contiguity nor action action items, while on the one loop and two loop items, measurement strategy did have a significant effect in the predicted direction.

Hypothesis 2 predicted that within each grade level, there would be a decreasing success as item complexity increased from stage 1 through stage 4, for both tasks. To evaluate this, we again looked at the percentage of correct responses for each stage, at each grade level, for both tasks.

This hypothesis was rejected for both tasks on the following basis. For the expression task, the prediction of decreasing succes with increasing item complexity was upheld for grade 3 only. For all other grades, there was not a strict negative relationship between item complexity and subject success, as predicted. For the reception task, the prediction of decreasing success as item complexity increased was upheld for grade 1 only. For all other grades, the comparisons of percentages of correctness was not as predicted. It was therefore concluded that within each grade level, the staged do not conform to a hierarchical sequence of increasing complexity.

Hypothesis 3 predicted a decreasing success with increasing item complexity for individual subjects, as opposed to grade level as in hypothesis 2. This was Miller et al's crucial hypothesis since, if most subjects conformed to this prediction, this would be an indication that the stages formed an invariant sequence. To test it, they determined each subject's proportion of correctness for each stage. If a subject's performance on the 4 stages decreased systematically with item complexity, the subject was scored as scalable. They reported that 91% of their subjects showed this scalability. They took this as an indication that the 18 items did indeed represent an invariant developmental sequence. We felt however, that their scalability method was somewhat unsophisticated and did not really measure item complexity, per se. The Guttman scaling technique is a more conventional method for evaluating this hypothesis and we therefore applied it to our data. Neither Index of Consistency was significant, indicating that the items cannot be considered to fall on a scale of more complex conceptualizations from stage 1 through stage 4. In other words, since the Guttman scaling technique showed that for neither task could the items be considered as scalable, then the 4 stages should not really be considered as representing a scale of invariant progressive development. Hypothesis 3 was rejected on these grounds.

Even though the Gutmann technique showed that the items were not scalable our results suggested that some of the ittems were at least different in difficulty. To test for statistical differences of difficulty between items for individual subjects, chi squares were generated.

For individual subjects in the expression task, chi squares showed that performance on the items differed at 3 points--between the contiguity/action items, and the one loop items, and the two loop items. For individual subjects in the reception task, chi squares showed that performance on the items differed only between the 2 least vs. the 2 most complex item groupings. This suggests that for the reception task, item complexity could only be differentiated at 2 points--between the contiguity/action items on the one hand, and the one loop/two loop recursions on the other hand.

In conclusion, the results from the language expression measure failed to replicate earlier finding that there was a 4 stage invariant sequence to the development of the understanding of recursive though t. More importantly, by relying on the language receptive abilities of children, our results again failed to replicate Miller's finding and therefore failed to support the proposition that there is a 4 stage sequence to this development. Rather, our results from the reception measure showed that recursive thinking develops according to 2 levels of complexity. The first level would be the understanding that one can think about people--either alone, or engaged in activity with one another. The second level would be the understanding that one can think about thinking, and that this process can be indefinitely extended in another's thoughts. That is, the second level would imply that one realizes that thinking can be an object to itself. Finally, our results showed that this development occurs at an age much earlier than had previously been found.

In as much as the total number of subjects was small, we view these finding as preliminary, yet promising. Further research is currently being conducted in this area of social cognition.